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THE DEADLY MICROBE AND ITS DESTRUCTION.

BY D. S. LAMB.

Microbes, Micro-organisms, and Germs.—There may have been microbes, there doubtless were, away back in prehistoric ages, perchance before the time of the great lizards and pterodactyls. Béchamp believes that he has isolated living microbes from the chalk of the Secondary Epoch, and Dr. Gautier claims to have recognized the odor of their remains in prehistoric guano, in bone caves of the Stone Age and age of the Cave bear. If all this is true, it shows astonishing vitality in these minute organisms. Not until that famous Dutchman, Anton Leuwenhoeck, looked through his microscope into some rain water and, for the first time in the history of the world, saw forms of minute life, not till then, in April, 1675, 217 years ago, did there dawn upon mankind the possibility of knowing anything of the microbes.

The improvements in the microscope have given us better observations and more exact results. The significance of many things at first but imperfectly understood is now better known. For instance, Dr. Pollender in 1855 and Dr. Brauell in 1858 noticed in the blood of animals dead of anthrax or the splenic fever numerous fine thread-like forms, which multiplied by division. It was reserved for that greater observer, Davaine, to recognize that these little threads were microbes and were the cause of the disease. This discovery was but the beginning of a long series, the end of which is not yet. There are at least 185 known microbes.

The origin of the word microbe was on this wise : At the meeting of the Academy of Sciences, Paris, March 11, 1878, there was a prolonged discussion as to whether these minute beings were animals or plants, microzoa or microphyta. Dr. Sédillon, as a sort of compromise, suggested that they be called microbes, which means small living beings. His suggestion was adopted. Since then, however, it has been settled that they are vegetal, having a cellulose covering, deriving their nitrogen from the salts of ammonia and nitric acid like other vegetal bodies. Their protoplasm, however, contains no chlorophyll or green coloring matter, and so is unable to decompose the carbonic acid of the atmospheric air; they are thus closely allied to the fungi. In some microbes the protoplasm contains sulphur or phosphorus; in others it does not. The effect of this difference in the chemical elements of their protoplasm is a varied reaction with staining agents, and this quality is a means of more readily identifying the varieties.

Microbes vary much in shape, and are named accordingly. The round or oval shaped is called a coccus. It reproduces itself by dividing into two of the same kind. These two together are called a diplococcus; these by subdividing may make a quartette, called a tetrad or merismopedia. Sometimes the subdivision forms a chain, called, therefore, a streptococcus. Each one of the subdivisions is a distinct and independent individual. The micrococci are also called spherobacteria.

Another form is the rod-shaped; the ends more or less rounded. This is called a bacterium or a bacillus; if somewhat curved in shape, often called vibrio. Heretofore the distinction between the bacterium and bacillus was mainly one of length; but it was soon found that this was not a very reliable distinction, and at the present day the name bacterium is applied to those which multiply only by division, while the name bacillus is given to those which have also the power of developing what are called spores. This whole group is also called microbacteria and desmobacteria. Another form yet is a spiral rod, called spirillum; called also spiro bacterium.

Still another form is the long thread or filament, called, when straight, a leptothrix; when wavy, a spirochæta.

The manner of reproducing by division or fission, as it is also called, has given to all of these microbes the name schizomycetes. It is worth while to mention that in nearly all animals and plants reproduction, development, and growth are effected by this multiplication by division.

As to size, microbes are very small, varying from a 500th to a 50,000th of an inch in greatest length.

They are found in the air and the water and soil. They may travel long distances by the winds and waters, and may live for a very long time. Their increase is favored by warmth, moisture, and the presence of organic matter. A bacterium may divide into two in the course of an hour; these become four in another hour; and at this rate of increase we will have in 24 hours from one bacterium nearly 17,000,000 individuals. In less than five days, at the same rate, they would fill all the great waters of the earth.

It is well to remember that a microbe which begins as a micrococcus may pass through the stages of bacterium and bacillus to that of spirillum. It is said, too, though this is also doubted, that a microbe which to-day is innocent—that is, will not produce disease—may to-morrow be hurtful. The oxygen of the air under pressure is known to modify its pathogenic or disease-producing power. Pasteur says that the oxygen of the air attenuates and extinguishes the poison. This fact may explain the spontaneous cessation of epidemics.

It has already been mentioned that some microbes are innocent—do not cause disease; but they nevertheless cause changes in organic matter. These innocent ones are in by far the greatest number, and by reason of this abundance interfere somewhat with our finding the hurtful ones.

The tenacity of life of the microbe is shown by the fact that many forms may be imbedded in ice without losing their vitality. Dr. Prudden has shown that certain bacteria may be frozen for 37 days and still be alive. Dr. Dornil, of Paris, has found that ice is often a medium of transmitting typhoid fever, and says that ice from rivers or ponds is as dangerous as the water itself.

The great factor in the distribution of most infectious diseases is human intercourse. At the present day the means and rapidity of intercourse are such that the danger of infection is much greater, and an epidemic spreads more rapidly and extensively than heretofore. Of course our methods of combatting disease are so much improved by isolation, disinfection, etc., that the terrible death-rate of past ages is not repeated in the present.

Examination of air to detect the presence of microbes has often been made, and the results show that they are in greater number in summer than during the other seasons, and appear to reach a maximum in August. Again, the higher we ascend in the air, the less the number. This is true of country and city. The air of the upper parts of the houses, the roofs, etc., contains fewer microbes than of the lower parts or the streets. The denser the population, the greater the number of microbes in the air. At sea, beyond, say, 120 miles from land, the air is generally free from them, although they are abundant in the sea water. The air of sewers has been examined by Carnelly and Pétri and found remarkably free from microbes, less, indeed, than the air outside the sewers. The explanation seems to be that in sewers there is no dust, the walls are moist, and the microbes are retained in the moisture. The liquid contents are alive with bacteria. These do not find their way into the air of the sewer unless fermentation takes place and bubbles of gas are disengaged or splashing occurs.

It may be said, in passing, that the microbes of the soil play an important part in the nutrition of the plants. They act on the soil in such a way as to cause oxidation of organic matter and ammonium, forming nitric acid, nitrates, etc., which, in solution, are absorbed by the rootlets of the plants. A gram of soil may contain as many as two millions of microbes.

River water and other surface water contain them in abundance. Waters like those of springs and deep wells, which have filtered through the soil, are in that way deprived of microbes. Filtration through finely divided coke or charcoal or sand gives the same result. Pasteur has shown that water forced through porous porcelain is entirely free from them. Filtration of river water through sand has reduced the proportion of them from 43 to 1. Water of deep wells filtered through chalk rocks shows a proportion still less.

There seems to be no reason to doubt that the same means which purifies water from harmless microbes will do the same for the hurtful ones. It is well to note that while ordinary drinking water is not a favorable medium for extensive growth of disease germs, yet, if these are in the condition of spores, they may be found quite permanently in any water, however pure.

In the process of decomposition of animal matter a class of poisonous substances is formed, called alkaloids: animal alkaloids, to distinguish them from vegetable; cadaveric alkaloids, as indicating their *post mortem* origin. They are also called *ptomains*. The presence of these ptomains explains the many cases of poisoning from eating decaying animal foods, as sausages, fish, tinned meats, ice cream, etc. Their formation is due to the action of putrefactive microbes on the albuminous substances of the dead tissue. It is probable that the microbe takes a certain amount of the carbon, hydrogen, etc., of the albuminous bodies for its own nourishment and multiplication, and the ptomains are found in the residue.

Similar poisonous alkaloids may appear in the *living* organism by a change of the protoplasm or decomposition of the albuminoids. These have been called *leucomains*. They are found in small quantity in normal human urine, and increase very much in number in certain infectious diseases.

A third class of substances similar to, but more poisonous than, the ptomains and leucomains has also been found in the living body, and they have been called extractives.

The great source of danger from microbes is believed to be in their poisonous products. In typhoid fever, Asiatic cholera, septicæmia, diphtheria, and some other diseases of this kind, the microbes produce the poisonous alkaloids and spread the infection. In cholera morbus there is a poisonous base called methylguanidin. Four alkaloids have been isolated from the bacillus which causes tetanus; they are called tetanin, tetanotoxin, spasmotoxin, and the fourth not named.

Pasteur believes that hydrophobia is due to a microbe which produces an alkaloid. The microbe itself has not been identified, but a poisonous ptomain has been obtained from the brain of rabbits suffering from the disease, and this ptomain produces the characteristic symptoms.

The comma bacillus of Professor Koch, called so from its resemblance to a comma, is undoubtedly the agent in causing Asiatic cholera. Alkaloids also have been found in the dejections in this disease.

The *bacillus typhosus* is found in typhoid fever; the alkaloid, however, called typhotoxin, is believed to cause the disease.

Malignant pustule, occurring especially in cattle, is due to a microbe called *bacillus anthracis;* the ptomain is anthracin.

Some ptomains are analogous, chemically, to certain vegetable alkaloids. Again, the same species of microbes will produce different ptomains, according to the organic substance in which they live.

Ptomains which are devoid of oxygen have a strong odor like musk, etc.; this odor is so persistent that, as previously stated, Dr. Gautier recognized it in the guano of prehistoric formation.

It is said that some microbes give rise to soluble ferments called *enzymes*, products of living protoplasm. Dr. Sheridan Lea has shown that the *micrococcus ureæ* secretes a ferment which converts urea into ammonium carbonate. Drs. Roux and Yersin have obtained a soluble poison from the cultivation of the *bacillus diphtheriticus*, which produces all the symptoms of diphtheria. It is an animal alkaloid, but a special ferment. It is proper, however, to say that the bacillus itself will cause the disease. In the case of the *bacillus anthracis*, the ferment produced will not cause the disease.

Pasteur has shown that if the blood of animals suffering with anthrax is filtered free from bacilli, the blood will not then cause the disease.

Drs. Lauder Brunton, and Macfadyen have shown by experiment that the microbes which liquefy gelatine do so by means of an enzyme. The enzyme can be isolated and its peptonizing action be demonstrated, apart from the microbes which produce it. For purposes of nutrition, microbes can form ferments adapted to the soil in which they grow.

The real cause of infectious diseases is, therefore, in some cases, the microbe; in others, the alkaloid or ferment, formed or secreted by the microbe. In most cases microbes produce both poisonous alkaloids and special ferments.

A few other interesting substances produced by microbes may be mentioned. The *torula cerevisiæ* or yeast plant, acting on sugar in solution, causes a fermentation which results in the production of alcohol and a residue. This is called the alcoholic fermentation. Again, the *bacterium aceti* produces vinegar in a pure state. The *bacterium lactis* acting on the sugar in milk produces lactic acid, causing the milk to become sour. All putrefaction results from the action of numberless microbes, the most important of which is the *bacterium termo.* The *bacillus butyricus* acting on butter makes it rancid; acting on cheese, causes it to ripen. The *bacillus tuberculosis* produces cellulose in the blood and tissues of tubercular persons, but does not produce an alkaloid.

Some microbes form pigment on the material in which they live. A few only of these are associated with disease. What is called indigo blue is produced by the action of a bacillus on indican, a substance existing in the indigo plant. This indican has also been found in human urine, especially in cases of intestinal obstruction and ulceration, and in granular kidney. The blue color of sweat is due to microbes. Many of these pigment-forming microbes are found in the air and give rise to patches of color on articles of food. The red spots which sometimes appear, especially on bread, and which in old times were supposed to be blood from the finger of an angry God, are known to be composed of groups of the *micrococcus prodigiosus.* Yellow milk is due to *bacterium xanthinum.* The blue color of litmus, used in testing acidity of fluids, is from the action of putrefactive microbes.

Some microbes acting on alkaline sulphates and organic matters in water, as in certain mineral springs, cause the freeing of the sulphur and disengagement of sulphuretted hydrogen.

Many of the lower animals have the power of making themselves phosphorescent. This luminosity is accompanied by the transition of peptones into organized living matter under the influence of free oxygen. This phosphorescence appears to depend on the action of certain microbes.

Experiments have been made to determine how great a degree of heat can be endured by them without being destroyed. The following are some of the results: The bacilli of anthrax and of swine plague were destroyed after exposure for one hour to a boiling temperature. The *spores* of the bacillus, however, required an exposure of four hours to the same temperature. As it is stated that none of the infectious diseases depend on the spores, it follows that their pathogenic microbes can be destroyed at a temperature of boiling point for one hour. Steam heat will destroy them and their spores in a little over five minutes.

On the other hand, many microbes will withstand a temperature of 90° F. without losing vitality, if the air is dry. *Tubercle bacilli* after being dried for three or four months may still be alive. Other microbes have been known to endure a tropical temperature in dry air for as much as three years. This endurance of heat and dryness is comparable to that of some of the lower animals. For instance, the anguillula has been found alive after two years desiccation; rotifers after four years, and some eel-worms after 30 years. The ability to endure cold has already been mentioned.

The action of electricity on microbes has been very little studied. Experiments show that the electric current is detrimental, and it is known that after a thunder-storm the microbes in the air are fewer than at any other time. Light is beneficial to some, detrimental to others. The same as to gases. Microbes which require free oxygen are called aërobic; the others anaërobic; but all require oxygen in some form. Compressed oxygen diminishes or destroys their vitality.

The condition of not being susceptible to infectious disease is called immunity. It is either *natural* or *acquired*. Some microbes will produce disease in some animals and not in others. The bacilli of anthrax will cause the disease in sheep and in man, but not in cats, dogs, or pigs. The bacillus of septicæmia, or what is commonly called blood-poisoning, will produce the disease in house-mice, but not in field-mice. These are cases of natural immunity. The acquired form is shown when an animal has an infectious disease, recovers, and then for a longer or shorter time it is not susceptible to another attack. The theory is that the microbes have consumed some element in the body which is essential to their growth and development. The body is, therefore, unfit to sustain a second crop, the soil is exhausted; and until this absent condition is restored the body is protected against another seizure of the disease.

Again, this constituent may be exhausted by a microbe which is less vigorous and destructive than the one which causes the disease, and, if this is done, then the introduction of the more vigorous one will fail to find anything to grow upon, and the individual is thus protected. This is the explanation of vaccination. The *attenuated* virus is a protection against the more poisonous virus.

This theory of *exhaustion*, as it is called, does not explain all the facts in the case; and the *antidote* theory of Klebs explains them more fully. His theory supposes that the microbes produce a substance which is poisonous to themselves in case they should reënter the same person at a subsequent time. There is some direct evidence in support of this theory.

The acquired form of immunity may be subdivided into that of acclimatization and that of inoculation.

People of tropical climates are less susceptible to the malarial fevers, etc., of their country than are strangers. This is acclimatization.

Vaccination, or protective inoculation, is the introduction into the system of a milder or weaker virus than that which produces the disease. In this way it is a protective in small-pox, yellow fever, splenic fever, chicken cholera, hydrophobia, swine fever, cattle plague, acute septicæmia, etc. There is no such protection, however, in such diseases as tuberculosis, pneumonia, erysipelas, malarial fever, relapsing fever, and breakbone fever. I have included tuberculosis here because I do not think, as yet, the inoculation of tuberculin, the modified virus of tuberculosis, has been proved to be a protection against the disease. In erysipelas, pneumonia, etc., one attack of the disease, so far from being protective against another, appears to increase the susceptibility.

The proportion of deaths from small-pox in 1,000 deaths from all causes is one-twentieth now what it was before vaccination was introduced. Deaths from splenic fever are one-twenty-fourth what they were before inoculation of the attenuated virus was practiced, and in hydrophobia, one-twenty-third. Some work has been done in inoculating against diphtheria.

I must pass over the discussion of how this milder virus is obtained and say something about germicides or microbe-destroyers; also called necrophytes. Two expressions are used in this connection which need to be explained. The word *antiseptic* is used, meaning *against poison.* Anything that retards or prevents the development of a poison is antiseptic. The same substance, if used in sufficient strength, may become an actual destroyer of germs. This we call a *germicide.*

There are many chemical agents which are antiseptic and germicidal. It would be very desirable, so far as microbe diseases are concerned, to be able to introduce into an animal, its blood, etc., this destructive chemical agent. The difficulty, however, is to use such germicide in sufficient strength to destroy the microbe and yet not injure the patient. It would be the height of therapeutic success if we could inject into the blood by means of a hypodermic syringe a little appropriate fluid and so stop the progress or prevent the development of an infectious disease—say, typhoid fever—by killing the microbes; or when the disease is caused by a poisonous alkaloid or special ferment, it would be desirable to neutralize these by some chemical agent and thus abort the disease. The destruction of the microbes in the first instance would, of course, prevent the formation of the alkaloids or ferments. I mention only a few of the more prominent of these microbe-destroyers.

The salts of mercury, especially the mercuric chloride or corrosive sublimate. A solution of this salt, one part in 1,000 to 5,000 of water, will destroy the most resisting organism in a few minutes. There is a difference of opinion as to whether such solution will destroy the spores, although the weight of evidence seems to favor the opinion that it will. This salt has been and is still very extensively used in surgery, midwifery, and ophthalmia of the new-born.

Iodine is a germicide and has been used hypodermically in splenic fever. In consumption also it has been used to diminish the number of bacilli and prevent the formation of spores, though its inhalation causes irritation and cough.

Sodium chloride, common table salt, is said to destroy the comma or cholera bacilli, but the microbes of typhoid fever, tubercle, cattle plague, etc., may remain in common salt for months without losing the power of growth and reproduction. The salting of meats, therefore, may be ineffectual in preventing the development of pathogenic microbes.

Sulphuretted hydrogen destroys the bacillus tuberculosis and is poisonous to nearly all other microbes. Dr. Bergeon and others have used this gas in consumption by injecting it per rectum. Claude Bernard has shown that gases which are poisonous when breathed may be introduced into the blood in some other way without poisoning. Bauman, a pupil of Liebig, claims to have cured consumption in the early stages by having the patients breathe in rooms in which sulphur was burning. For the first ten days the cough and irritation increased; afterwards the patients rapidly improved.

Free oxygen is germicidal to some microbes. Ozone is found especially in the high regions of the atmosphere and in sea air. Microbes are least numerous in these regions. Ozone destroys microbes, and it is supposed that it does so by decomposing organic matter and setting free the oxygen. The advantages of residence of consumptives in high altitudes, as the Swiss mountains, is partly explained in this way. Oxygenated water acts like ozone.

Air saturated with oil of turpentine is germicidal. There is a popular and seemingly well-grounded belief that the air of a country well wooded with turpentine trees is useful in preventing and curing consumption. Skoda says that moist air with turpentine vapor is useful in gangrene of the lungs.

The salts of quinine destroy both pathogenic and non-pathogenic microbes. They destroy the *bacillus malariæ*. The best salt for therapeutic purposes is probably the hydrochlorate. The dose by mouth must be proportioned to the severity of the case or intensity of the poison. Stanley, in Darkest Africa, took doses of 45 to 50 grains.

The alcohols are antiseptic and germicidal; will arrest the development of microbes and spores; but the spores, once formed, are said to resist strong alcohol for months. The destruction and prevention of putrefactive germs is well shown in the use of alcohol in laboratories of anatomy, pathology, etc.

There are many other lesser germicides which I need not stop to mention. The tendency of the present day is to rely less on disinfectants and more on absolute cleanliness. If we should visit one of our best hospitals we would see the ceilings and walls painted, because it has been found that wall-papers accumulate germs and dust; the paint can be readily cleaned. There are no carpets on the floors nor woolen curtains at the windows, because of the same objection; the floors are painted, varnished, or oiled;

the windows are shaded by shutters or light curtains. Water pipes, closets, and bath tubs are exposed, so that dirt cannot accumulate nor leakage occur without being at once noticed. Gas is replaced by electricity to avoid contamination of the air by the products of combustion. Hot air from a furnace is replaced by hot-water heating, or the air is screened as it enters the building. The water used for drinking and the preparation of food is boiled to free it from possible organic substances that might be hurtful. Every other possible precaution is taken to prevent the introduction of poisonous microbes. The instruments used in operations are made entirely of metal, and can be placed, box and all, in boiling water before using, to destroy all possible germs. The operator keeps himself clean; wears overgarments of linen or some non-woolen material. The subject for operation is handled only so much as is necessary; only a limited number of assistants and spectators may be present. The effect of all this precaution has been to diminish largely the mortality; serious consequences which formerly were not unexpected would now be an opprobrium to the operator and the hospital. Speaking generally, such a place is far better for treatment of sick and injured than any private house, even that of the most wealthy.

The diseases which are known or believed to be caused by microbes, or their products, are about 40 in number. Among them are cerebro-spinal meningitis, chicken cholera, Asiatic cholera, so recently at our doors; dental caries, which is the staff of life to thousands of dentists; diphtheria, erysipelas, glanders, hydrophobia, leprosy, malaria, measles, pleuro-pneumonia, puerperal fever, pyæmia, scarlet fever, swine fever, tetanus, commonly known as lock-jaw from one of its prominent symptoms; tuberculosis, typhoid fever, small-pox, vaccine disease, and yellow fever. These diseases are most dreaded; they decimate populations, and yet are most easily prevented.

In hydrophobia or rabies there is a micrococcus, which, however, has not yet been isolated and cultivated, found in the nervous system.

In yellow fever micrococci are found in the kidneys, spleen, and liver. The disease is worse during the heated term and ceases with frost.

In erysipelas they are found in the lymphatic vessels of the skin.

In small-pox, also in the lymphatics of the skin.

In pneumonia, in the sputa and blood. The disease can be produced in some of the lower animals by spraying the microbes in the animals' cages.

In whooping-cough an oval-shaped micrococcus is found, but has not yet been isolated.

In measles, micrococci are found in the skin, blood, and catarrhal exudations.

In scarlet fever, in the blood, exudations, ulcerated throat, scaling of skin, and in urine; found also in the milk of cows suffering with certain diseases of the udder.

In gangrene there are small oval micrococci.

In cattle plague, micrococci are found in blood and lymphatic glands.

In cerebro-spinal meningitis, in the pus at base of brain and in kidneys.

In puerperal fever, found in endocardium, lung, spleen, kidney, brain, etc. An alkaloid has also been found in the organs of those dead of the disease and in the urine of patients. To prevent the fever, an antiseptic treatment of the lying-in patient should be adopted.

In what is called suppuration the microbe *micrococcus pyogenes aureus* is found.

In septicæmia, micrococci and bacteria are found in great numbers.

In chicken cholera the *bacteria choleræ gallinarum* is found in large numbers in the blood and organs of fowls dead of this disease. A culture injected into the blood-vessels of a chicken or rabbit develops the characteristic symptoms. Guinea pigs, however, are said to have immunity.

In diphtheria a bacillus and an enzyme are found. The bacillus is in the diphtheritic membrane, but not in the blood of diseased organs. The cat, cow, and Guinea pig are liable to the disease if inoculated with the bacillus.

In typhoid fever, the bacillus typhosus; found in Peyer's glands, spleen, larynx, lungs, liver; sometimes in kidneys and urine, and in blood. The disease has been reproduced by inoculating pure cultures. The stools of patients are highly infectious and should be disinfected before being thrown away. Mercuric chloride or ferrous sulphate may be used for this purpose.

In malaria the *bacillus malariæ* is found in the spleen and marrow in the form of threads and spores. The microbe was first discovered in the soil of the Roman Campagna. It flourishes in marshy districts, deltas, alluvial soils, and banks of tropical rivers. It is found abundantly in the blood in malarial diseases, and is said to be inhaled, but may perhaps be taken up by the skin or stomach. It is wafted by winds, floating about six feet above the ground, and is stopped by mountains and belts of trees. An amœbiform organism has also been found in the blood in this disease; if injected into the veins it gives rise to intermittent fever.

In glanders or farcy the *bacillus mallei* has been found in the lungs, liver, spleen, and nasal membranes of horses, sheep, and men dead of the disease.

In leprosy, the *bacillus lepræ*. The disease is both contagious and hereditary. If the cultures are introduced into the system of an animal they produce the disease. The disease is common in parts of Africa, South America, Southern Asia, and some of the Pacific islands. It is incurable.

In tuberculosis or consumption, the *bacillus tuberculosis* is found in sputum, blood, tissues, urine, etc., and in the tubercles themselves. Inoculated in animals, it produces the disease. The bacillus forms cellulose from the tissue. Not only man, but the cow, goat, sheep, horse, pig, carnivorous animals, fowls, and rodents are susceptible. It grows more readily in animals which are omnivorous or herbivorous. Galtier says that cheese and whey from the milk of tuberculous cows often contain the bacilli. Swine and poultry fed on these dairy products often develop the disease. Their flesh in turn may give the disease to man.

The expectorated matter of tuberculous patients is highly infectious, even after having been dry for several months. The bacilli may enter the system by breathing or swallowing, or directly by a scratch or cut. Boiling milk and thorough cooking of meats of animals suspected of having the disease destroy the bacillus. Persons suffering with the disease should sleep by themselves, for many have contracted it by occupying the same bed with a patient. All causes which weaken the constitution increase the susceptibility and hasten the progress of the disease.

In anthrax or malignant pustule or splenic fever the *bacillus anthracis* is found in blood and tissues of animals, and causes the disease. Those who handle the hides, wool, or hair of animals dead of the disease are liable to contract it, either by breathing the spores or by a wound in the skin. The animals should be cremated. It is said that the bites of fleas can carry the infection. Animals grazing on the land previously occupied by diseased animals are liable to be infected.

In swine fever a bacillus is found in lungs, spleen, liver, intestine, and serous membranes of pigs dead of the disease. Inoculations of pure cultures produce the disease in those susceptible, as pigs, rabbits, mice, and pigeons. It may be so cultivated as to be modified. When this modified form is inoculated the animals become proof against a fatal attack.

In Asiatic cholera the *bacillus choleræ* or *comma bacillus* is always found in the rice-water stools of patients sick or dead of the disease.

In tetanus, bacilli which produce spores. These inoculated in mice and rabbits reproduce the disease.

Yellow fever spreads by means of moist winds and human intercourse. Water and soil seem to have nothing to do with it. It prevails in plains near the sea-coast and along the course of great rivers.

Cholera follows the course of rivers. A moist atmosphere and soil are necessary. Moist winds are the great agents of distribution. Troops, pilgrims, and emigrants spread the disease far and wide.

Malarial diseases are more prevalent in moist than in dry weather. Moisture in the soil is necessary to their production ; clayey, loamy, marshy soils favor the development. In marshy districts the larger the amount of organic matter in the soil, the greater the amount of malaria. The lower the level of the country, the more prevalent the disease, although in Central Africa a height of 2,500 feet is not free from it. Air, water, and food may convey it.

In conclusion, I would remark that the discovery of these microbes, the study of their life history and products, and their causative and other relations to disease have done much to simplify treatment. Generally speaking, these diseases run a definite course, which can be but little, if at all, shortened by any treatment. The treatment is, therefore, directed towards making the patient comfortable, keeping up his strength, preventing complications, controlling his personal hygiene and his surroundings, and in other ways avoiding death and promoting recovery. This is the true idea of cure, which is to take care of. The mortality is much lessened ; the consequences are much less serious.